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THE WORK OF JOSEPH HENRY IN RELATION TO APPLIED SCIENCE AND ENGINEERING[1]

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THE pioneer work of Joseph Henry in physics, and especially in its department of electromagnetics, has justly claimed the principal attention of his biographers and students. Certain aspects of Henry's work in the physics of electromagnetic induction were the theme of that fine presentation last year by President J. S. Ames, of the Johns Hopkins University, in the first Joseph Henry lecture of this series. Henry also accomplished, however, so much in applied physics that without detracting in the least from his fame as a pure scientist and researcher in basic physics, it seems proper to consider, in this second Joseph Henry lecture, his achievements in relation to applied science and engineering.

[1] The second Joseph Henry Lecture, delivered before the Philosophical Society of Washington on April 23, 1932. The lecture was illustrated by lantern slides showing Henry's apparatus, as taken from authentic sources.

As it is sometimes difficult to distinguish between basic and applied science, when considering the manifold occupations and accomplishments of a scientific pioneer like Henry, we may be permitted to consider as basic those scientific studies directed to the development of a field of knowledge *per se;* and as applied science or engineering, those studies directed to utilities, as well as to the field itself. So interwoven, however, are basic and applied science, and especially in physics, that the distinction between them may sometimes be reduced to mere differences in the attitude of the researcher's mind. One and the same piece of scientific research may be regarded as either basic, or applied, or both, according as the researcher directed his mind to the field of knowledge itself or to its utilization, or to both.

Henry's accomplishments in applied science are notable in the following fields:

I. Civil Engineering.
Surveying and Geodetics.
II. Electrical Engineering.
(*a*) Lifting electromagnets.
(*b*) Electromagnetic telegraphy.
(*c*) Elementary electromagnetic motors.
(*d*) Lightning protection.
(*e*) Electro-ballistics.
III. Mechanical Engineering.
(*f*) Building stone tests.
IV. Acoustical Engineering.
(*g*) In buildings.
(*h*) In fog-signalling.
V. Illumination Engineering.
(*i*) In light-house development.
VI. Meteorological Engineering.
(*j*) Forecasting from telegraph bulletins.

It may be noted that among the 148 publications appearing in the "List of Professor Henry's Scientific Papers," printed in the Annual Report of the Smithsonian Institution for 1878 and the *Bulletin* of the Philosophical Society of Washington, Vol. II, nearly forty relate to scientific applications.

Surveying and Geodetics

In 1825, New York State appointed commissioners to survey the route for a state road from the Hudson River to Lake Erie, a distance of over 500 km. Henry was appointed an engineer on this survey. The route he followed was from Kingston, near West Point, on the Hudson, to Portland Harbor on Lake Erie. He acquitted himself so well in this survey that an effort was made to have him appointed permanently as state engineer. In 1829, he read a paper,[2] published in the Transactions of the Albany Institute, which is a topographical report covering a considerable part of the state of New York, giving tables of distances and elevations along various routes. His paper gives a clear description of the topography of the country along these routes. It states:

> The elevations in Table No. 1, between the Hudson River and Bath, are from the survey of William Morell, Esq. The remaining elevations of this Table, as well as those in No. 2, are from the personal survey of the writer of this article.

These levelling surveys had to be carried over some very difficult stretches of country, including sections of what was, at that time, primeval forest. Henry seems to have taken so much interest in this work that it may have been a matter of good fortune for both basic and applied science, when he was diverted from the profession of engineering by the vacancy of the chair of mathematics and natural philosophy in the Albany Academy.

[2] "Topographical Sketch of the State of New York Designed Chiefly to Show the General Elevations and Depressions of its Surface." "Scientific Writings of Joseph Henry." I: 8–36, Smithsonian Institution Publication, 1886. *Trans.* Albany Inst., I: 87–112.

Electrical Engineering

The traction or sustaining electromagnet: Sturgeon, in England, had announced, in 1825, the production of the first horseshoe electromagnet. It consisted of a bar of soft iron bent into horseshoe form, insulated on its surface by a coat of varnish, and with bare copper wire wound over it in separate spires. When a voltaic current was passed through the copper wire, the horseshoe became magnetized, and would lift an iron rod laid across its poles.

The laws controlling the force of attraction between the electromagnet and its soft iron keeper, or armature, are complicated and were not worked out in detail for practical applications until many years later. They involve a combination of electric current in the electric wire circuit and of magnetic current or flux in the magnetic circuit.

Henry, experimenting with electromagnets at Albany, N. Y., in the years 1828–1831, succeeded in establishing certain fundamental principles, as to the conditions in both the electric and magnetic circuits, for securing the maximum attractive force from a given horseshoe electromagnet. At the same time, he greatly improved the winding on the magnet by using insulated wire in many close turns. At that time, of course, there were no instruments for measuring electric current. He made a series of electromagnetic measurements with three controlled elements, *viz.:*

(*a*) the number and the size of the voltaic cells in the exciting circuit of the electromagnet.
(*b*) the length of extra copper wire introduced into this circuit.
(*c*) the number of series or parallel windings on the electromagnet.

Under these controlled variations, he measured the attractive force, in pounds weight, exerted by the magnet.

In cooperation with Dr. Ten Eyck, he showed, from a number of such measurements, that the greatest attractive force or lifting power[3] could be obtained from a horseshoe electromagnet by the use of a "quantity battery" together with a "quantity winding" on the magnet, provided that the battery and magnet were close together and connected by short lengths of wire. That is, the battery should have only one cell and its plates should be of large surface. The magnet windings should be connected in parallel. On the other hand, when the battery and magnet were

[3] "Scientific Writings of Joseph Henry." I: 37–53, Smithsonian Institution Publication, 1886. *Silliman's Am. Journ. Sci.*, 19: 400–408. Jan., 1831.

far apart and had to be connected by a long wire, the best arrangement for attractive force on the armature was to use an "intensity battery" and an "intensity magnet," *i.e.*, the cells of the battery should be connected in series, and also the windings of the magnet. He points out that this combination has a bearing upon the problem of an electromagnetic telegraph. If, however, an intensity magnet has to be used, with all its turns in series, then for best tractive effort an intensity battery should be placed in the circuit, whether the connecting wires between them are short or long.

All of these principles, enunciated by Henry, more than a hundred years ago, are still fundamentally correct. The terminology, however, has been greatly changed, partly through the widespread knowledge of Ohm's law ($I = E/R$) of current in an electric circuit. Dr. Ohm had already published, in Berlin, his essay containing that law[4] in 1827, but the publication received very little attention, and did not find its way into text books on physics until some twenty years later. It did not come into electrical applications until after 1840, in the early development of telegraphy, and after instruments had been produced for measuring electromotive force, resistance, and current. The above mentioned results which Henry published in 1831, were far in advance of the knowledge in electromagnetics at that time.

In one set of measurements he describes his electromagnet as made of a cylindrical bar of soft iron 1/4 inch (0.64 cm.) in diameter, wound with about 8 feet (2.4 m.) of insulated winding with perhaps 100 turns. When this winding was excited by one copper-zinc voltaic cell with plates of 28 sq. in. (180 sq. cm.) immersed in dilute acid, the weight lifted by the magnet was 4½ lbs. (2 kg.). When a length of 1060 feet (320 m.) of copper bell wire 0.045 inch (1.14 mm.) in diameter was inserted in the circuit between voltaic cell and magnet, the lifting power of the magnet fell to about half an ounce (14 gm.) The resistance of the length of copper specified would to-day be about 5.5 ohms; but at that date, when high-conductivity copper was not in demand, it may readily have been nearly 12 ohms.

With an intensity battery of 25 zinc-copper cells in series and with the same active area of plate surface in each cell as before, the magnet lifted 8 ounces (227 gm.), with the whole length (320 m.) of copper wire inserted in the circuit; so that changing from 1 cell to 25 cells, increased the lift from 14 gm. to 227 gm., with the whole length of wire included. Short circuiting the long copper wire, or connecting the 25-cell series battery to the magnet terminals, gave no increase in lifting power. Indeed the lifting power observed was somewhat less (7 oz. or 198 gm.). It will be remembered, however, that the plain zinc-copper battery of those days was subject to marked polarization and variation of electromotive force, while in action. The effect of changing the battery from one cell to 25 in series, increased the lift from 14 gm. to 227 gm., with the long wire in circuit; but with the long wire cut out, the lift fell from 2,000 gm. to 227 gm. This was the first published demonstration of the importance of using a series-connected, or intensity battery, to increase the tractive power of an electromagnet of many turns through a considerable length of external circuit.

Discussing the remarkable power of the intensity battery to overcome the effect of inserting the 320 meters of extra copper wire in the circuit, Henry remarks:

> On a little consideration, however, the above result does not appear so extraordinary as at first sight, since a current from a trough possesses more "projectile force" to use Prof. Hare's expression, and approximates somewhat in intensity to the electricity from the common machine. May it not be a fact that the galvanic fluid, in order to produce its greatest magnetic effect, should move with a small velocity . . . ? . . . From these experiments it is evident that in forming the coil we may either use one very long wire, or several shorter ones as the circumstances may require; in the first case our galvanic combinations must consist of a number of plates so as to give "projectile force," in the second it must be formed of a single pair.

Here Henry uses the term "projectile force" to designate what we call to-day "electromotive force" and "velocity of magnetic fluid" for what we now call "current strength." He is evidently not far from a conception of Ohm's law, which had already been formulated mathematically by Ohm four years before. By the term "trough" in the above quoted passage, Henry evidently means a series-connected battery, with the elements arranged in the form of a trough. Also by the term "common machine" he doubtless refers to either the frictional or the induction electric machine, which were the only electric generators known, prior to Volta's discovery, in 1800, of the voltaic pile.

In the same publication, Henry goes on to describe the construction of a larger electromagnet, a model of which, kindly loaned to us by the Smithsonian Institution from its museum, is shown here this evening. The magnet had a winding of 9 coils of insulated copper wire arranged to be connected either in series or in parallel combinations. The total weight of the magnet was 21 pounds (9.5 kg.). It was excited by one zinc-copper dilute acid cell with con-

[4] "Die galvanische Kette mathematisch bearbeitet." Georg Simon Ohm, Professor of Physics at Munich. Berlin, 1827.

centric plates. The effects were tried of various winding combinations on the sustaining power of the magnet. The maximum was reached at 750 pounds (340 kg.), when all the windings were connected in parallel, or as a "quantity" winding. The magnet thus lifted more than 35 times its own weight, with the aid of a single exciting cell, a very remarkable achievement for the year 1831.

In a communication to *Silliman's American Journal of Science*[5] in April, 1831, Henry describes a yet larger horseshoe electromagnet, constructed for Yale University. It weighed 59½ pounds (27 kg.) without its multiple-coil winding. Excited with a single zinc-copper dilute acid cell, it supported a weight of 2063 pounds (937 kg.).

Electromagnets for raising and carrying masses of iron are in fairly extended engineering use at the present day, and Henry's pioneering work at the Albany Academy from 1827 to 1832 clearly pointed the way to that electrical application.

The electromagnetic bell signalling instrument here shown, from the Smithsonian Museum collection of Henry apparatus, is a replica of an apparatus made and used by Henry, in 1832, for sending audible electromagnetic signals through a wire more than a mile in length. This apparatus is not referred to in Henry's paper of 1831, but appears in Henry's statement to the Board of Regents of the Smithsonian Institution for 1857, together with testimony to show that the instrument was exhibited in 1832, at the Albany Academy.[6]

"I arranged around one of the upper rooms in the Albany Academy a wire of more than a mile in length, through which I was enabled to make signals by sounding a bell. The mechanical arrangement for effecting this object was simply a steel bar, permanently magnetized, of about ten inches in length, supported on a pivot, and placed with the north end between the two arms of the horse-shoe magnet. When the latter was excited by the current, the end of the bar thus placed was attracted by one arm of the horse-shoe and repelled by the other, and was thus caused to move in a horizontal plane and its further extremity to strike a bell suitably adjusted."

The original Henry instrument is kept in the Palmer Laboratory Museum at Princeton, where Henry set it up, and is reported on good authority to have been used as a signalling device, in his house on the Princeton University campus, operated by electric current from his laboratory, probably in the basement of Nassau Hall.

Henry declared that he never in his life filed an application for a patent of invention. In this technical sense, therefore, he was not an inventor; but in a broad sense of the term, he was undoubtedly a great inventor; because in making researches in basic science—his selected field of work—he often indicates through his writings that he realized from time to time possible applications for his discoveries, while leaving to others the tasks of introducing them into industrial service. He always admitted that Morse was the inventor of the electric telegraph bearing that name, but Henry has recorded the following claims:[7]

"From a careful investigation of the history of electromagnetism in its connection with the telegraph, the following facts may be established:

(1) Previous to my investigations, the means of developing magnetism in soft iron were imperfectly understood, and the electro-magnet which then existed was inapplicable to the transmission of power to a distance.

(2) I was the first to prove by actual experiment that in order to develop magnetic power at a distance a galvanic battery of 'intensity' must be employed to project the current through the long conductor and that a magnet surrounded by many turns of one long wire must be used to receive the current.

(3) I was the first to actually magnetize a piece of iron at a distance, and to call attention to the fact of the application of my experiments to the telegraph.

(4) I was the first to actually sound a bell at a distance by means of the electro-magnet.

(5) The principles I had developed were applied by Dr. Gale to render Morse's machine effective at a distance."

There can be no doubt that Henry's electromagnetic researches found abundant application in the magnetic telegraph.

Voltaic-battery mechanism for series-parallel connections: Henry published, in 1835, an illustrated description of a machine which he designed and constructed at Princeton for swiftly changing a voltaic battery of 88 cells, from series to parallel combinations, so that they might be, in the extreme cases, either all in series or all in parallel.[8] The various pairs of plates were held in a rigid wooden frame, and each plate had a little metallic cup fastened to it for holding a small quantity of mercury. Metallic bars of suitable size and shape, served to connect the cells in series or in parallel.

[5] "An account of a large electromagnet, made for the laboratory of Yale College." "Scientific Writings of Joseph Henry." I: 50–53, Smithsonian Institution Publication, 1886.

[6] "Statement in relation to the history of the electromagnetic telegraph." Smithsonian Annual Report for 1857, pp. 90–106. "Scientific Writings of Joseph Henry." II: 420–437, Smithsonian Institution Publication, 1886.

[7] "Scientific Writings of Joseph Henry." II: 435–436, Smithsonian Institution Publication, 1886.

[8] "Description of a galvanic battery for producing electricity of different intensities." "Scientific Writings of Joseph Henry." I: 80–86, Smithsonian Institution Publication, 1886. Trans. Am. Phil. Soc., 5: 217–222. Jan. 1835.

The same plan in essentials, is very generally employed to-day with storage-battery installations for charging them in parallel and discharging them in various series combinations for high-tension service. Henry's apparatus was thus a pioneer form of voltaic-battery engineering design.

Electromagnetic engine or early form of electric motor: On the table, is the replica of Henry's early form of reciprocating motor driven by voltaic-battery power. This replica is also loaned by the Smithsonian Museum. The original is preserved with the Henry apparatus at Princeton University.

The little engine is described by Henry in a letter to the editor of *Silliman's American Journal of Science*[9] published in July, 1831, in the following terms:

"Sir: I have lately succeeded in producing motion in a little machine by a power, which, I believe, has never before been applied in mechanics—by magnetic attraction and repulsion.

Not much importance, however, is attached to the invention since the article, in its present state, can only be considered a philosophical toy; although, in the progress of discovery and invention, it is not impossible that the same principle, or some modification of it on a more extended scale may hereafter be applied to some useful purpose. But without reference to the practical utility, and only viewed as a new effect produced by one of the most mysterious agents of nature, you will not, perhaps, think the following account of it unworthy of a place in the *Journal of Science.*"

The apparatus consists of a pair of vertical permanent magnets, which, in modern parlance, are the *field magnets* of the little machine. As described in the paper, their north poles are uppermost. A soft iron bar, pivoted about a horizontal axis, and wound with insulated wire, is free to oscillate over a certain range under the magnetic forces of the upright permanent magnets. This oscillatory electromagnet corresponds to the *armature* of a modern direct-current motor. At the free ends of the rocking armature are stiff projecting copper wires, arranged to dip into mercury cups at each end in such a manner that the current from a voltaic cell is caused to reverse the magnetization of the rocker bar near the end of each stroke, and so reverse the magnetic forces on the rocker bar. In this rocking commutator, we have the precursor of the *rotating commutator* of the modern motor.

Henry thus produced what was probably the first electric motor device, although in the progress of the art, its reciprocating motion had to be converted into rotary motion, before practical success was attained with motors.

Lightning protection: Henry was a close observer of atmospheric electric phenomena, and contributed a number of articles to the literature of the subject at different times. He also, however, formulated a set of rules or directions[10] to be followed for the protection of houses from lightning. These rules would probably be regarded as good engineering specifications against lightning damage at the present date.

Electro-ballistics: In 1843, Henry communicated to the American Philosophical Society, a paper[11] "On a new method of determining the velocity of projectiles." He describes a chronograph drum, revolving at a uniform speed of at least 10 turns per second, so as to permit of high-speed ballistic records upon its surface. Two copper wire screens are placed successively in the path of the projectile whose speed is to be measured. The projectile cuts the wire in the screens so as to interrupt a voltaic circuit through each, at the instant of its passage. These circuit interruptions are automatically recorded on the surface of the drum, either by the deflection of magnetic needles, or by electric sparks puncturing a sheet of ruled paper on the drum. The sparks are caused by induction coils.

The method and system, as described, constitute an electrical-engineering invention in ballistics.

MECHANICAL ENGINEERING

Testing of building materials: In August, 1855, Henry read a paper before the American Association for the Advancement of Science, "On the mode of testing building materials." The President of the United States had appointed a commission of five persons in 1851, "to examine the marbles which were offered for the extension of the United States Capitol" at Washington. Another commission of three persons was appointed in 1854, to repeat and extend some of the experiments. Henry was a member of both commissions and evidently took upon himself a large share of the experimental work.

Small cubical blocks of the marbles to be compared were tested in a press for resistance to crushing. A long series of tests, made in this manner, brought out some remarkable and unexpected results. It was shown that when the crushing stress was exerted on the blocks with thin sheets of lead inserted between the press plates and the pressed block surfaces, the blocks gave way at about half of the pressure they

[9] "On a reciprocating motion produced by magnetic attraction and repulsion." "Scientific Writings of Joseph Henry." I: 54–57, Smithsonian Institution Publication, 1886.

[10] "Construction of Lightning Rods," "Scientific Writings of Joseph Henry." II: 398–402, 1859, Smithsonian Institution Publication, 1886. Also "On the Protection of Houses from Lightning," *Proc.* Am. Phil. Soc., June 20, 1845.

[11] "Scientific Writings of Joseph Henry." I: 212–215, Smithsonian Institution Publication, 1886. *Proc.* Am. Phil. Soc., 3: 165–167. May, 1843.

could sustain when the lead sheets were not used. The account is, in effect, an engineer's report.

Acoustical Engineering in Buildings

In the *Proceedings of the American Association for the Advancement of Science*[12] for August 1856, Vol. X, pp. 119–135, Henry published a remarkable paper, "On acoustics applied to public buildings." He states that Prof. Bache and he had directed attention to the subject of acoustics as applied to buildings, when the President of the United States had referred to them the plans for the construction of rooms in the new wings of the Capitol at Washington. They visited, with this object, the principal halls and churches in Philadelphia, New York and Boston. The final plans of the new rooms were approved and successfully built.

They also had designs prepared for the new lecture hall of the Smithsonian Institution, and incorporated into them various acoustic principles their researches had brought out. These researches are most interestingly described in the paper. Henry, in this research, was an acoustical engineer, with his aim directed on improving the acoustic properties of the lecture hall. He was, however, also a pioneer investigator of interior acoustics, considered as a basic science. He says (p. 419):

> "These researches might be much extended; they open a field of investigation equally interesting to the lover of abstract science and to the practical builder."

In this passage is revealed that remarkable duality of Henry's mind which appears again and again in his writings. He studies a subject for a utilitarian purpose as an engineer, and enriches its basic science, while at another time he studies a new field as a physicist, and suggests intuitively to the reader where practical applications are likely to be found. He was *par excellence* a combination of physicist and engineer.

The acoustic properties of the Smithsonian lecture hall appear to have been very satisfactory and to have endorsed the special acoustic features introduced into its construction.

Fog-signal Acoustics

Congress established the U. S. Lighthouse Board in 1852, with Henry as one of its members. Later, as chairman of its Committee on Experiments, he directed, in 1865, a series of acoustic researches on fog signals, that were not only of basic scientific importance, but also of great engineering value. He showed experimentally that beyond relatively short distances, artificial sound reflectors were of no avail. To eliminate the personal equation in acoustic observations of this kind, he describes an artificial ear or "phonometer," for making feeble sound waves perceptible to the eye.

These researches of Henry appeared as unsigned reports of the Light House Board, but were subsequently included in his published papers. These reports contain comparisons of the acoustic ranges attained, under normal atmospheric conditions, by steam whistles, trumpets, and sirens. Such comparisons were made over short ranges by phonometer, and over long ranges by ear, on small vessels making exploratory trips for purposes of the test. They are acoustic-engineering reports of great interest. They were made at various times from 1865 to 1877.

In the course of these tests, Henry closely investigated the abnormal conditions of the appearance of fog signals at shorter and longer ranges, with their concurrent disappearance over a certain intermediate range, or belt of silence. These occasional but practically important acoustic anomalies, were referred to by Henry in two presidential addresses before your Society, one[13] on December 11th, 1872, when Dr. Tyndall was present, and the other[14]—his last address to you—on November 24th, 1877.

Illuminating Engineering

Lighthouse development: In the Report of the Lighthouse Board for 1875, pp. 86–103, Henry points out that in 1852, when the Board[15] commenced its operations, sperm oil was the fuel generally employed. The steadily rising cost of sperm oil made it desirable to find some less expensive substitute. A series of experiments was commenced with lard oil, which was then much cheaper, but not regarded as capable of use in powerful lamps.

Commencing with a pair of small conical lamps having "single-rope," as distinguished from tubular wicks, one burning sperm oil and the other lard oil, the two commenced nearly at equality of candle-power, by photometer; but after burning for three hours the lard-oil lamp fell to about one-fifth of the photometric power of the sperm-oil lamp. On analyzing the reasons for the falling off in candle-power of the lard-oil flame, Henry was led to the conclusion that the capillary flow or liquidity of the lard oil in

[12] "Scientific Writings of Joseph Henry." II: 403–421, Smithsonian Institution Publication, 1886.

[13] "Remarks on Some Abnormal Phenomena of Sound," Smithsonian Report 1878, pp. 490–496.

[14] "The Method of Scientific Investigation and its Application to Some Abnormal Phenomena of Sound," Bull. Phil. Soc. Washington, 2: 162–174.

[15] "Scientific Writings of Joseph Henry." II: 477–510, Smithsonian Institution Publication, 1886.

the wick is relatively defective. This, however, was found to be affected by the temperature of the oil, so that by raising the temperature of the lard oil to about 250° F., the liquidity of the lard oil became greater than that of the sperm oil. When, therefore, the conditions of oil feeding through the wick of a large burner raised the temperature sufficiently, the lard oil should be capable of competing on favorable terms.

After further preliminary trials with larger tubular-wick burners, the experiment was carried to Cape Ann, Massachusetts. Here were two twin lighthouses, only 275 meters apart. One of these was operated with sperm oil, as usual, and the other with lard oil, each lamp being so trimmed as to exhibit its greatest capacity.

"It was found by photometric trial that the lamp supplied with lard oil exceeded in intensity of light that of the one furnished with sperm oil. The experiment was continued for several months, and the relative volume of the two materials carefully observed. The quantity of sperm oil burned during the continuance of the experiment was to that of lard oil as 100 is to 104."

A long series of photometric measurements at Boston is then described, with the substitution of the Bunsen grease-spot photometer head for the earlier Rumford shadow comparator. An improved photometer for measuring the candle-powers of burners using different oils, was also set up at the Smithsonian Institution.

As a result of improvements in lamp mechanism, as well as in the substitution of lard oil for sperm oil in all of the lighthouses of the United States, a great reduction was effected by 1866, in the annual cost of lighthouse oil.

This published account of lighthouse research is a fine engineering report, containing many basic scientific suggestions of great interest. Later on, the price of lard oil began to rise and a new series of researches was undertaken leading to the introduction of mineral oil, which was attended at first by a number of special difficulties.

Meteorological Engineering

Applications of Telegraphy: In our daily contact with the service of the Weather Bureau, which displays coastal storm warnings in advance of expected heavy gales, and furnishes daily weather forecasts, with maps, showing the principal meteorological conditions, at a given hour each day, over the North American continent, it is hard for us to realize the corresponding conditions that existed, say, in 1845, before Henry left Princeton and when there was no way of foretelling the approach of a coming big storm, except such as could be guessed by any single observer at one spot, and before the general laws of revolving storms had been arrived at.

Henry devoted much time to the study of meteorology, which evidently exerted a fascination for him throughout his life. The first page of his published papers gives abstracts of his first known scientific contributions (Proceedings of the Albany Institute in 1825 and 1826)—communications dealing respectively with "Chemical and mechanical effects of steam" and "Refrigeration by rarefaction of air." Among his published papers are 38 that bear by title upon meteorology. According to the account by his biographer, W. B. Taylor, read before this Society, October 26th, 1878, Henry's last feeble utterance on his dying day, May 13th, 1878, was a meteorological[16] enquiry.

Henry's early studies of weather, when he was at Albany, convinced him of the importance of securing simultaneous observations of barometric pressure, air temperature and humidity, wind velocity, cloud conditions and precipitation, at as many different stations as possible. In 1849, while the telegraph system of the country was only a few years old, it was organized with the aid of voluntary observers into a network by which a weather map could be made up each day at the Smithsonian Institution. Henry urged that every telegraph operator, coming on duty at a certain morning hour, should open with a definite meteorological message. This plan manifested its utility, but placed too heavy a burden on the Institution. In 1870, a meteorological office was established by the Government under the Signal Office of the War Department. This office was finally transferred to the Weather Bureau, created in 1891, under the Department of Agriculture. The early development of the Weather Bureau, was thus a telegraph-engineering development due to Henry's persistent labors in meteorology.

Conclusions

From what has been above excerpted from Henry's writings, it will be seen that this many-minded man, who made so many notable contributions to basic science, also contributed much to applied science.

When, therefore, it is justly claimed for Joseph Henry that he was a scientist-discover, writer, organizer, and administrator, it can be confidently added that he was also an inventor and engineer.

[16] "A Memoir of Joseph Henry," A sketch of his scientific work by William B. Taylor. Read before the Phil. Society of Washington, October 26, 1878, pp. 230–268. Phila., 1879. Smithsonian Coll., 21: 360.

OBITUARY

NATHAN AUGUSTUS COBB

ON June the fourth, Dr. N. A. Cobb, principal nematologist of the Bureau of Plant Industry, U. S. Department of Agriculture, died suddenly and unexpectedly from a heart attack at Johns Hopkins Hospital, where he had gone for an annual health examination.

Born in Spencer, Massachusetts, on June 30, 1859, he received his early education there, graduated from Worcester Polytechnic Institute, was teacher in his home town and later professor of chemistry and natural science at Williston Seminary. He acquired his Ph.D. in Jena, Germany, under Häckel, Oscar Hertwig, Kükenthal, Lang and Stahl. After a stay at the Zoological Station in Naples he went to Australia, where he first was *locum tenens* professor of biology for the then Professor Haswell on leave at Sydney University, N. S. W. Already booked for return to the United States, he received the appointment as pathologist of the New South Wales Department of Agriculture, cancelled his passage and remained in Australia. He was for a time manager of the Wagga Experimental Farm and during 1898-1901 was appointed commissioner of his department to Europe and the United States. The years 1904–1907 see him in Hawaii as head of the division of pathology and physiology of the Hawaiian Sugar Planters' Association. He left there to join the staff of the Bureau of Plant Industry, U. S. Department of Agriculture, first as agricultural technologist, then for a short time as assistant chief, and later on as he specialized more in nematology, as principal nematologist.

Dr. Cobb embodied all that is meant by a scientist. His interests were broad and his knowledge extended into almost all branches of science. If scientists can be classed, according to Ostwald, as romanticists or classicists, Dr. Cobb undoubtedly belonged to the former, being of an enthusiastic, visionary type, often ahead of his time.

As were his faculties so were his contributions to science of a most varied character. An early contribution concerned the flora of his home country. The bachelor's thesis "Mathematical Crystallography" discussed the application of analytical geometry to crystallography and developed some new demonstrations analogous to those of Miller, who applied spherical trigonometry to the same subject. This mathematical view of Dr. Cobb shows up all through his later work in biology as a tendency to formulate not only for life phenomena but even for life forms short mathematical expressions. His familiarity with mathematics, especially with its optical application, made him the skilful microscopist for which he was famous. He combined with this gift an innate ability to draw. His artistic sense was highly developed; he could become exalted over a good woodcut. In fact, this artistic talent influenced not a little his own course of life. While in Jena as a student he was introduced by Häckel to the famous oceanographer and member of the Challenger Expedition, Sir John Murray. A collection of exceedingly neat and accurate water color figures of various biological subjects so impressed Sir John that he was instrumental in the appointment of the young American zoologist to the table of the British Association for Advancement of Science at the Zoological Station in Naples.

In Jena, Dr. Cobb first came in closer touch with the subject on which he later concentrated his life work. Kükenthal, himself a specialist on whales, had brought back from a study trip a barrel filled with whale nematodes. These became the subject of the American's doctor's thesis. Through Bastian's, Bütschli's and de Man's publications his attention was directed to the free-living forms. Jena's neighborhood was the first successful hunting ground and a few such forms could be included in his thesis. In Naples he acquainted himself with marine types and his fascination grew. Here was an almost unnoticed, seemingly unlimited world of life forms. Small they were and because of their structure a difficult subject, but for Dr. Cobb just the one thing to try his skill. In this field he excelled and his work here will undoubtedly survive that of many a contemporary zoologist. He was a keen morphologist but never stopped at structures, which for him were primal to functions.

The familiarity with agricultural problems, especially plant diseases and soil fertility, enabled him first to recognize and second to emphasize the economic and practical significance of this group of animals for which he coined the shorter term nemas. When he first claimed nematology to be a branch of science perhaps analogous in nature and extent to entomology, he was thought to be an enthusiast, obsessed with the importance of his work. But developments have fully sustained his views.

It was as pathologist of the New South Wales Department of Agriculture that possibly the widest range of problems faced him, problems which frequently lay far from the lines of his education. Yet Dr. Cobb attacked them in a masterly manner, even in cases where he was an outsider in the branch of science involved. Often laboratory facilities and apparatus had to be provided by his own labor and ingenuity. Numerous papers concerning most varied

subjects of plant pathology, the growing of wheat, diseases of stock, wild animals, and again and again nematodes, date from this period. Not less significant were his contributions to the problem of sugar-cane growing. In the U. S. Department of Agriculture, Dr. Cobb was closely connected with the first and perhaps most fundamental work on the standardization of cotton fibers. Who does not know his picture of the house fly, perhaps one of the most widely reproduced of scientific pictures drawn with so much ingenuity. Whoever heard and saw the results of his bird studies, especially on the bluejays, will admire the skill, the keenness, the patience and the enthusiasm that were his.

He had an inborn tendency to rationalize the methods of investigations, inventing and constructing various devices and apparatus to this end. Naturally this rationalization did not stop at his laboratory door. He saw with concern the endless irrationalities in our daily life. Why not simplify where it is possible? For years he advocated the adoption of the metric system. While in Australia he tried to impress upon people the obsoleteness of the English monetary system. His last public address as retiring president of the Washington Academy of Sciences, was a call to scientists to assume more leadership in such matters. Science complicated life, the scientist therefore should lead in simplifying it. Why burden our children with the learning of obsolete systems when much simpler ones are at hand? Why should human society, even in matters of science, use a variety of languages when one, perhaps a modernized English, could be used?

Dr. Cobb was of a charming personality. All who came in personal contact with him admired his ever open interest in most varied matters, his ability to discuss the widest range of subjects, and to portray clearly his views, often spiced with "Attic salt." In fact his sense of humor was very keen and occasionally found its expression in verses and rhymes. He captured his associates by an ever young enthusiasm for his work and an unlimited optimism.

His favored society was the Helminthological Society of Washington, of which he was a charter member. The informal character of this society, which offered so much opportunity for free discussion, was to his liking. He rarely missed a meeting and rarely failed to make one or more communications. Dr. Cobb was past president of the Washington Academy of Sciences and a former president of the Helminthological Society of Washington, the American Society of Parasitologists and the American Microscopical Society.

G. STEINER

SCIENTIFIC EVENTS

THE NORTH INDIA EXPEDITION OF YALE UNIVERSITY

THE Yale North India Expedition has found fossil plants and mollusc shells in the Himalayas which will throw new light on the subrecent climatic changes in this region, according to the first report of the expedition made to President James Rowland Angell by the director, Professor Hellmut de Terra. This group of scientists has already spent three months in exploring the western Himalayas and adjoining regions, and will continue its studies for another nine months.

Surveys in this region indicate the geologically recent origin of the southern Himalayan range. The expedition has spent some time in the northern Punjab, south of the Himalayas, making collections of invertebrate and vertebrate fossils with the assistance of a member of the Geological Survey of India. Mr. G. E. Lewis, of Yale, the paleontologist of the party, has found interesting representatives of the celebrated fossil mammal fauna of this region.

The very extensive series of lakes and swamps in the Kashmir Valley has been investigated by Professor G. E. Hutchinson. The collections and ecological data amassed will undoubtedly add to our knowledge of the relations of this fauna to that of western Central Asia from which region Kashmir has received most of its animal inhabitants. The contrast of this fauna with that of the rest of India is most striking.

The Himalayan area is of special interest since it is the scene of geologically recent mountain building. Strata which are so young as to be contemporary with formations laid down during the Ice Age in Europe and America have in this region been folded and pushed out of their original positions by the great pressure of mountain-making. A study of the animal and plant life in the inland waters here give some idea of the river systems and ancient geography of this land.

Through the generosity of an anonymous donor the American Geographical Society has enabled the expedition to enlist the services of a topographer who joined the expedition through the courtesy of the surveyor general of India. The surveyor, Khan Sahib Afraz Gul Khan, plans to map a hitherto unsurveyed part of the great Karakorum Range north of the Himalayas. The expedition has left Srinagar, capital of Kashmir, and will spend five months in Little Tibet.

UNEMPLOYMENT AMONG CHEMISTS AND CHEMICAL ENGINEERS

Industrial and Engineering Chemistry urges federal subsidizing of research in universities by unemployed chemists. It asks support of a plan proposed by the New York Committee on Unemployment and Relief for Chemists and Chemical Engineers, whereby idle research chemists would be engaged in fundamental research in universities and scientific institutions, jointly subsidized by the federal government and the universities themselves.

The committee's proposal involves the application of some portion of public or semi-public relief funds, to salaries for unemployed research chemists who would be put to work under the supervision of the heads of the chemistry and chemical engineering departments in various universities, with the universities paying the full cost of laboratory materials and operating expenses.

Departmental heads of almost every university and technical institution in the metropolitan district of New York have approved the plan. The research projects to be undertaken would be directed toward the widening of fundamental knowledge and not toward the improvement of industrial processes.

By far the largest group among the 632 unemployed chemists and chemical engineers registered were formerly engaged in research. Indications are that several large industrial organizations have dismissed research staffs in recent months. It is partly to meet this situation that the committee has formulated its proposal. There are in all eighty-two fields represented by the registrants. One hundred and seventeen more than one sixth of the total, were research chemists. Many have pure research theories of great interest which they are eager to work out, but for which they lack the means.

The committee, which has since January placed 128 men and women, fifty-three in permanent and seventy-five in temporary positions, has made an appeal to members of the chemical profession for funds to carry it through the summer, original donations from the ten sponsoring societies being nearly exhausted. Complete registration of all unemployed chemists within fifty miles of the city is being sought.

Applicants, 60 of whom formerly earned over $5,000 a year, include 123 who are completely destitute, 145 who are in need, 177 who have funds enough to hold out a short while longer, and 187 who do not need relief. There are thirty-two women chemists registered. Jobs obtained for applicants, it was estimated, have averaged in salary from $35 to $50 a week. Four have been secured at $100 or more a week, and several very highly specialized jobs have been left unfilled because none of the registrants had had experience in the particular fields required. The committee estimates that there are about 1,500 unemployed chemists in the district. Mr. Frank G. Breyer is executive chairman of the committee and R. T. Baldwin, treasurer.

HONORARY DEGREES AT HARVARD AND YALE

THE eleven honorary degrees conferred at the Harvard commencement exercises included doctorates of science on Professor R. A. Millikan and Professor Lawrence J. Henderson and a doctorate of laws on Professor John Dewey. President Lowell's citations were as follows:

ROBERT ANDREWS MILLIKAN: Eminent physicist, who with tireless zeal has studied the constitution of matter and the nature of interstellar space.

LAWRENCE JOSEPH HENDERSON: A prolific thinker who by chemistry, mathematics and philosophy has revealed the mechanism whereby blood makes possible the higher forms of life.

JOHN DEWEY: Most renowned of living American philosophers, we rejoice to add our sprig of laurel to his crown.

At Yale University ten honorary degrees were awarded of which two were on men of science. Professor Phelps presented the candidates and President Angell conferred the degrees as follows:

FIELDING HUDSON GARRISON

Professor Phelps—Librarian of the Institute of the History of Medicine at Johns Hopkins. Dr. Garrison belongs to that noble company from Sir Thomas Browne to Harvey Cushing who have combined the science of medicine with the art of literature. Lieutenant-Colonel of the Medical Corps in the United States Army, author of many scientific and biographical works, Dr. Garrison holds a unique position in America. His Introduction to the "History of Medicine" is the foremost reference book in English. In all phases of medical and biological history he is a master. While editing the Surgeon General's Catalogue and the "Index Medicus" he wrote the most accurate and readable "Life of Josiah Willard Gibbs" and in 1915 a Memoir of John Shaw Billings. Many specialists think of him mainly as the author of the "History of Anatomic Illustration before Vesalius," but his friends know him as an excellent musician, and a competent authority on the history of music and the history of Spanish poetry. As a linguist, he is familiar with nearly all modern European languages, including Russian. His versatility is as remarkable as his accuracy. He is a rewarding mine of information. As a librarian, he distributes books wisely, for he has written many of them and read all the rest. He is a cheerful man; happy in himself, and the cause of happiness in others.

President Angell—Most eminent of American scholars in a difficult field, where your extraordinary literary

gifts have been wedded to profound scientific knowledge and unflagging industry, Yale University confers upon you the degree of Doctor of Letters, admitting you to all its rights and privileges.

FRANK RATTRAY LILLIE

Professor Phelps—Zoologist. Born in Toronto, student of that university, he took his doctor's degree at the University of Chicago. Like several other million scholars, he was a member of the faculty of the University of Michigan, the foremost professorial training school in America. He is professor of embryology at the University of Chicago, dean of the School of Biological Science and Medicine, director of the Marine Biological Laboratory at Woods Hole. He is a member of many learned societies in Europe and in America. He has to an extraordinary degree combined executive management with individual research. His investigations in embryology, cytology and physiology have won for him an international reputation. The growth of the famous laboratory at Woods Hole is a monument to his scientific and administrative ability. He has taken a leading part in the organization of biological research, having trained a large number of young men, who are inspired both by his teaching and by his example.

President Angell—A distinguished biologist, a sound and fruitful investigator, a stimulating teacher and trainer of men, your long career has been marked by constant advance to larger and more important achievement. In recognition of your eminent services, Yale confers upon you the degree of Doctor of Science, and admits you to all its rights and privileges.

SCIENTIFIC NOTES AND NEWS

DR. EDWARD LAURENS MARK, Hersey professor of anatomy, emeritus, at Harvard University, attained his eighty-fifth birthday on May 30. In recognition of the event, his colleagues, friends and former students arranged in his honor a dinner which was held on the evening of May 27 at the Faculty Club. After dinner Professor H. W. Rand, of Harvard University, introduced speakers who made brief congratulatory and reminiscent addresses. Those who spoke were: Dr. C. B. Davenport, of the Carnegie Institution; Professors Ephraim Emerton, E. H. Hall and F. W. Taussig, of Harvard University; Dr. F. B. Lund, of Boston; Professor F. T. Lewis, of the Harvard Medical School; Professor H. V. Neal, of Tufts College; Professor R. P. Bigelow, of the Massachusetts Institute of Technology; Professor J. F. Fulton, Jr., of the School of Medicine of Yale University. After the addresses Dr. Mark replied.

THE honorary degree of doctor of science was conferred by the University of Maryland on Dr. A. F. Woods, director of scientific work of the Department of Agriculture, at commencement on June 4. Dr. Woods was president of the University of Maryland from 1917 to 1926. In addition, the Alumni Association at its annual luncheon presented to the university a full-figure, life-size oil portrait of Dr. Woods, as a recognition of his accomplishments for the university during his presidency.

THE commencement exercises of the Johns Hopkins University included the presentation to the university of portraits of Dr. Hugh H. Young, clinical professor of urology, and Dr. Dean Lewis, professor of surgery.

THE doctorate of science has been conferred by Wesleyan University on Dr. Duncan S. Johnson, professor of botany and director of the Botanical Garden at the Johns Hopkins University; on Dr. Alfred L. Loomis, the physicist, Tuxedo Park, New York, and on Dr. Henry S. White, professor of mathematics at Vassar College.

AT the one hundred and thirty-eighth commencement of Williams College, an honorary degree of doctor of science was conferred upon Dr. Chester N. Myers, the organic chemist, of New York City.

THE Rensselaer Polytechnic Institute conferred at commencement honorary degrees of doctor of engineering on Dr. William Lispenard Robb, head of the department of electrical engineering for the last thirty years, and on Clarence F. Hirshfeld, chief of the research department of the Detroit Edison Company.

THE Worcester Polytechnic Institute recently conferred the doctorate of engineering on Alfred D. Flinn, director of the Engineering Foundation, New York City.

THE degree of doctor of science was conferred on June 13 by the Michigan State College at Lansing upon Dr. Lyman J. Briggs, assistant director for research and testing of the National Bureau of Standards.

THE honorary degree of doctor of science was conferred on June 15 on William A. Hamor, of the Mellon Institute of Industrial Research, at the fifty-second commencement of Grove City College, Pennsylvania.

DR. CARL NEUBERG, director of the Kaiser Wilhelm Institute for Biochemistry, Berlin, has been elected an honorary member of the Danish Biological Society.

SIR HENRY WELLCOME, founder of the Wellcome Research Institution, has been elected an honorary

fellow of the Royal College of Surgeons. Sir Henry is the second person not holding a medical degree on whom this distinction has been conferred, the other being Lord Roberts of Kandahar.

As reported in *Nature*, British knighthood has been awarded as follows: Dr. H. B. Brackenbury, chairman of the council of the British Medical Association; Mr. R. H. Davis, governing director of Messrs. Siebe Gorman and Company, Ltd., inventor of the Davis submarine escape apparatus and of a submersible decompression chamber for use in deep-sea diving; Dr. Robert L. Mond, president of the Faraday Society and of the Egypt Exploration Society; Mr. MacPherson Robertson, for services in connection with the Antarctic Research Expedition, 1929–31, and Professor W. Wright Smith, regius professor of botany in the University of Edinburgh and regius keeper of the Royal Botanic Garden, Edinburgh.

A CORRESPONDENT of the American Medical Association writes that the distinguished Spanish histologist, S. Ramon y Cajal, has passed his eightieth birthday, but that the anniversary passed unobserved by his pupils and friends. When he was seventy years old, his bust was unveiled. He spent his eightieth birthday, as every day of his life, over his microscope.

DR. OTTO STRUVE, assistant director of the Yerkes Observatory, has been appointed director of the observatory and professor of astrophysics at the University of Chicago, from July 1. He succeeds Professor E. B. Frost, who retires at the end of the present academic year. Professor Frost will continue to reside at Williams Bay.

PROFESSOR W. F. GANONG, since 1894 professor of botany and director of the Botanic Garden at Smith College, retires this June under the age limit, and has been made professor emeritus. He will continue residence for the present at Northampton.

THE Board of Trustees of Wellesley College has made Dr. Margaret C. Ferguson research professor of botany. She retires from active service in the department of which she was appointed chairman in 1904. Dr. Ferguson will continue her cytological and genetical studies of *Petunia* at the college. Dr. Laetitia M. Snow has been appointed professor of botany and has been granted leave of absence for the coming year. She will continue her work on bacteria in windblown sand at the Hopkins Marine Station, Pacific Grove, California.

AT Cornell University Dr. Cornelius Betten has been named dean of the university faculty, filling the vacancy created two years ago by the retirement of Dean W. A. Hammond. Dr. Carl E. Ladd has been appointed dean of the Colleges of Agriculture and Home Economics; Dr. W. A. Hagan becomes dean of the College of Veterinary Medicine, and Miss Flora Rose succeeds to the position of director of the College of Home Economics.

AT Harvard University Dr. Frederick H. Verhoeff, professor of ophthalmic research since 1924, has been appointed director of the Howe Laboratory of Ophthalmology; Dr. Theodore J. Blanchard Stier, instructor in general physiology, has been appointed associate director of the laboratory of general physiology, and Dr. John T. Edsall, instructor, will become assistant professor of biological chemistry and tutor in the biochemical sciences.

PROMOTIONS to professorships at the Massachusetts Institute of Technology include: Carl G. A. Rossby, meteorology; Dr. Louis B. Slichter, geology, and Dr. Norbert Wiener, mathematics.

DR. M. C. WHITAKER has been elected a director and vice president of the American Cyanamid Company, New York City.

DR. ABRAHAM WHITE has been appointed Porter Fellow for the year 1932–33 by the council of the American Physiological Society.

DR. EARLE R. HEDRICK, professor of mathematics and chairman of the department of mathematics of the University of California at Los Angeles, has been appointed chairman of a committee on the teaching of mathematics in the colleges and universities of the North Central Association. His headquarters for the summer will be divided between the University of Minnesota and the University of Chicago. Members of the committee include Professor H. E. Slaught, professor of mathematics at the University of Chicago, and Professor Dunham Jackson, professor of mathematics at the University of Minnesota.

D. E. BULLIS, who has leave of absence from the Agricultural Experiment Station at Oregon State College, has undertaken chemical research on low-temperature food preservation for Pacific Frosted Foods, Inc., at Oakland, California.

DR. ARNOLD A. ZIMMERMANN, assistant professor of anatomy in the College of Medicine of the University of Illinois at Chicago, will be a laboratory guest of the Wistar Institute of Anatomy, Philadelphia, during the next two months. He plans to make a study of the lymphatics of the developing opossum.

DR. JOSEPH A. CUSHMAN, director of the Cushman Laboratory for Foraminiferal Research, at Sharon, Massachusetts, and two assistants will spend this summer in Europe making studies of the types of European Cretaceous foraminifera, comparing these directly with the Cretaceous fauna of America.

These studies were made possible by grants from the Milton Fund at Harvard University and the Permanent Science Fund of the American Academy of Arts and Sciences.

DR. ROBERT CUSHMAN MURPHY is now in England superintending the packing and shipment of the Rothschild collection of birds which has been acquired by the American Museum of Natural History.

DR. GUY E. PILGRIM, who recently retired from the India Geological Survey after a service of thirty years, is visiting the United States.

DR. HARLOW SHAPLEY, director of the Harvard College Observatory, delivered the commencement address at the University of Pennsylvania.

DR. WILLIAM L. RUSSELL, professor of psychiatry, Cornell University Medical College, has been appointed Thomas W. Salmon Memorial Lecturer for 1933. Dr. Adolf Meyer, Baltimore, recently delivered the first series of these lectures, established in January, 1931, in memory of Dr. Salmon, professor of psychiatry at Columbia University, College of Physicians and Surgeons.

THE Alpha Alpha chapter of the honorary physics fraternity, Sigma Pi Sigma, was installed at the University of Chicago on June 6. Twenty-one members were initiated as the charter group, including Dr. Henry G. Gale, head of the physics department, and Dr. Harvey B. Lemon, faculty adviser of the new chapter. The installing officers were Dr. Marsh W. White, of the Pennsylvania State College and executive secretary of the society; Dr. M. N. States, national president, and Mr. A. W. Coven. After the installation dinner at the Quadrangle Club the members and guests from near-by chapters of the fraternity inspected the new Science Museum being developed under the direction of Professor Lemon.

PUBLIC lectures at the New York Botanical Garden during July and August are: "Forestry and Forest Planting," Dr. Forman T. McLean, supervisor of public education; "Crops and Civilizations," Dr. Elmer D. Merrill, director-in-chief; "Summer Wild Flowers," Dr. John Hendley Barnhart, bibliographer; "Lilies," Dr. A. B. Stout, director of laboratories; "The Plant Life of the Sea," Dr. Marshall A. Howe, assistant director; "Deserts of the South-west," Dr. Arthur Hollick, paleobotanist; "Jungles and Gardens in Florida and Elsewhere," Dr. H. Beaman Douglass, physician; "Summer Garden Flowers," Mr. Kenneth R. Boynton, head gardener; "Gladiolus," Dr. Forman T. McLean, supervisor of public education. The lectures are given on Saturdays at 3:30 in the afternoons.

Museum News reports that the New York Zoological Society has remodelled the one-story brick building, south of the Aquatic Bird House in the Zoological Park, and has equipped it as a laboratory for the tropical research department. There is a main laboratory room, 36 by 26 feet, a library and record room, and two additional rooms for library and storage. The department's collections installed in this building include all the specimens taken during the British Guiana, *Noma*, *Arcturus*, Haitian and Bermuda expeditions; also the paintings and drawings made during these expeditions.

THE Rockefeller Foundation is reported in the London *Times* to have offered a grant of $40,000 to the department of physics at the University of Durham.

Nature writes that the Committee of Management of the Lewis Evans Collection of Scientific Instruments has issued its annual report. Details are given of the important collection of astronomical, optical, magnetic and mathematical instruments presented by the Royal Astronomical Society of London. This collection is especially valuable as illustrating the period in the history of astronomical measuring which immediately preceded the time when photographic methods began to be employed for the accurate determination of stellar positions.

ACCORDING to *Museum News*, a plan to assist members of the museum profession during the coming season by giving them preferential consideration in making up lecture programs has been suggested by the council of the American Association of Museums. The council urges that, so far as possible, museums that are arranging lecture programs engage lecturers who are connected with museums. Museums are invited to send to association headquarters at Washington the names of members of their organizations who would like to obtain lecture engagements at other museums, together with notes as to the subjects on which speakers are prepared and any other facts that will be helpful. Lists of such speakers will be made available for distribution to museum authorities who may desire such data in arranging their schedules.

MR. CAMILLE BLAISOT, French minister of public health, has decided, according to the Paris correspondent of the American Medical Association, on the manner of distributing the sum of 385,000,000 francs, which has been placed by parliament at the disposal of his department as a portion of the appropriations made for the improvement of the national equipment for the promotion of public health. The dominant idea governing the distribution was the desire to use the appropriated sums chiefly for undertakings that would necessitate the employment of a large amount of man power. The distribution as affecting hospital

centers was influenced, in part, by a consideration of the needs and the local possibilities for absorption of the appropriated sums during 1932. For the hospital units the subsidies allowed amount to 180,000,000 francs. Subsidies amounting to 30,000,000 francs were accorded to societies that support the crusade against child mortality. The sum of 5,000,000 francs was granted to the vacation camps and the camps located adjoining hot springs. As regards the organizations carrying on the crusade against the social diseases, it will be observed that the anticancer centers are to receive 27,000,000 francs; the societies devoted to the eradication of venereal disease, 16,000,000; the sanatoriums, 33,000,000; the preventoriums, 21,250,000; the antituberculosis dispensaries, 2,960,000, and the schools for the training of nurses, 15,590,000. Certain societies that have an appeal from the scientific or social point of view are to receive efficient financial aid; such, for example, as the Institut du radium of the Curie Foundation, 12,500,000 francs; the anticancer center at Villejuif, 12,500,000; the Renaissance sanitaire (hospitals of the mutual aid societies), 11,500,000; the Ecole de puériculture de la Faculté de médecine de Paris, 8,091,000; the Foch Foundation, 4,000,000, and the society for the mutual protection of railway employees, 2,000,000.

IT is reported in the London *Times*, that after having been lost, perhaps for centuries, fossils which formed part of the first geological collection at Oxford have been discovered at Oriel College. The discovery is announced by Mr. R. T. Gunther, curator and secretary of the Lewis Evans Collection, which is housed in the Old Ashmolean Museum. In the annual report Mr. Gunther states that the collections illustrating the original association of the Old Ashmolean with the study of natural history in Oxford have received a most unexpectedly appropriate addition from Oriel College in the form of a small oak chest-of-drawers containing some early natural history specimens dating from the beginning of the eighteenth or perhaps from the end of the seventeenth century. The college has had this cabinet cleaned and repaired and deposited with the Lewis Evans Collection for examination, with the result that some of the contents have been discovered to be a part of the great Lhuyd collection of fossils which passed to Oxford at the death of Edward Lhuyd, the Celtic scholar and naturalist and second-keeper of the Old Ashmolean. How the fossils came to be removed from the Old Ashmolean and lost will probably always remain a mystery. Most of the fossils are inclosed in their original paper wrappings inscribed with the name of the locality and a serial number, all of which have been discovered to agree with the descriptions written by Lhuyd and published by him in 1699 in his pioneer work on British paleontology. The fossils that have been discovered are therefore of the highest historical interest, not only because they were part of the first geological collection in Oxford and a part of the world-famed Ashmolean collection, but especially because they are the original type specimens described and in some cases figured by Lhuyd in his classical work.

DISCUSSION

THE WORD ALGEBRA

FEW terms in elementary mathematics have such an interesting history as the word algebra. In the first place it is one of the few mathematical terms which were derived directly from the Arabian language and point to the time when the center of mathematical activity was among the Arabs and the Persians. In the second place a number of different views as regards the meaning of this term have been published, and quite recently Professor O. Neugebauer, Göttingen, Germany, supported a view which is in disaccord with the ones commonly adopted in our histories of mathematics and elsewhere. This view was published earlier as a hypothesis by S. Gandz and appears now also in the opening note of volume 2 (1932), "Quellen und Studien zur Geschichte der Mathematik," part entitled Studien.

It is well known that the term algebra has been derived from the title of a work written in about 825 by a Persian mathematician named Mohammed ibn Musa, al-Khowarizmi. The title of this work has been transliterated somewhat differently in various of our larger dictionaries as well as in the histories of mathematics. One of these transliterations is as follows: *al-jabr w'al muqabalah*. A common translation of the former of these terms, which actually gave rise to the word algebra, is the transformation of an equation which involves positive and negative terms so that only positive terms appear in each member of the equation, and it has been noted that the Greek mathematician Diophantus emphasized this transformation. In the article noted in the preceding paragraph Professor O. Neugebauer supports the view that *muqabalah*, which is the second term in the given title, is simply the Arabic translation of the former term in the title which is of Assyrian origin and means an equation.

If this view is correct practically all the explanations of the meaning of the term algebra which appear in the literature are in need of revision. What is

perhaps more important in this connection is the fact that there seems to be no scientific reason why the common explanations of the terms in question were adopted. These explanations seem to have originated at a time when it was customary to publish historical views without any supporting evidences and to assume that interesting views which appeared reasonable should be regarded as correct as long as they could not be disproved. Fortunately, the history of mathematics is now rapidly abandoning some of these views and the evidences reported in the article noted above make it very probable that the wide-spread views in regard to the term algebra will soon belong in this category, and that this term has a much more dignified etymological meaning than has been commonly supposed.

G. A. MILLER

UNIVERSITY OF ILLINOIS

CROSS-INOCULATION STUDIES WITH SPECIES OF THE GENUS RHIZOBIUM ON THE ROOTS OF FLORIDA LEGUMES

IN the year 1886 Hellriegel and Willfarth made the brilliant deduction that legumes succeeded in very poor soil because of the presence of nitrogen-fixing bacteria in the root nodules. Since that time wide recognition has been given to the importance of inoculation in the cultivation of leguminous crops.

The question of specificity of these nodule bacteria for the host plant was investigated by J. Simon in 1914 and by many others since that time. At present there seem to be eighteen recognized plant groups as determined by cross-inoculation tests. There are still many uninvestigated species of cultivated and wild legumes bearing root nodules. The aim of this project is to classify on a cross-inoculation, morphological, physiological and serological basis the bacteria from as many of Florida leguminous species as facilities will permit.

Since Crotolaria has become an important forage and cover crop and several inquiries have been made concerning inoculating material, it was decided to consider the bacteria from the species of this genus early in the course of the investigation.

Satisfactory cross inoculations were made on *Vigna sinensis* with nodule bacteria isolated from the following species of Crotalaria: Alata, falceta, hilderbranti, incana, intermedia, maxillaris, mundyi, oocarpa, polysperma, rotundifolia, spectabilis and mysorensis. Also, bacteria from nodules of *Erythrina herbacea, Clitoria ternata, Aeschynomene americana* and *Colopagonia mucunoides* produced good nodules on the roots of *Vignia sinensis*. Attempts to make similar crosses with cultures from *Crotalaria angyroides* and other species failed or were unsatisfactory.

Bacteria isolated from nodules on the roots of *Trifolium procubiens* gave good inoculation on the roots of *Trifolium hybridum*.

Details with references and acknowledgments will appear later.

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THE PRESENCE OF A DISTINCT INSULIN IN DEPANCREATIZED DOGS AFTER PANCREATECTOMY[1]

THE criticism of the above article by Soskin (SCIENCE, April 8, 1932) is based upon a misconception of the purpose of the article. Its purpose was to logically demonstrate the existence of a distinct insulin in depancreatized dogs after operation, and was not an attempt to reinterpret any findings of his, or to discuss the "Overproduction Theory of Diabetes," which I have thoroughly treated in another recent communication.[2]

The sole purpose of my article was to prove that there must be, of necessity, some form of insulin present other than the pancreatic, in the dog after operation, because carbohydrate metabolism still continues, and the heat and energy released in this process is still furnished to the dog for its life functions during a period of 18 days.

As my main premise I use the fact established by my own calculations from the table of Soskin's Dog No. 6, Table IV—that this dog, entirely deprived of its pancreas, still metabolizes 60 per cent. of the total glucose of its food.

Two other minor premises support the preceding: (1) Animals below vertebrates oxidize glucose and deposit glycogen without the aid of a pancreas since they have none; (2) Glucose can not be oxidized nor glycogen deposited without the assistance of insulin (all severe diabetic cases prove this).

From the above premises I derive the final conclusion that an extra-pancreatic (or cellular) insulin must exist in the dog after pancreatectomy.

The consideration of R. Q's, D to N ratios, blood sugars, increased or decreased "gluconeogenesis," and other disputed variables, have no part in the simple argument and conclusion stated; nor does the fact that a few eminent research workers have failed to extract cellular insulin from animal tissues militate at all against the strength of the above argument, since the period of over 30 years between the time of Minkowski and Banting was filled with dozens of

[1] *N. E. Jour. of Med.*, Jan. 7, 1932.

[2] *Medical Times and Long Island Med. Jour.*, February, 1932.

similar unsuccessful attempts to extract pancreatic insulin.

Suffice it to say in conclusion that attempts by various new methods are now being made by a small group of the most expert and practical insulin workers of the country, to extract this insulin, although its existence must be considered as already proven by other indisputable facts.

GEO. H. TUTTLE, M.D.

SOUTH ACTON, MASS.

SOCIETIES AND ACADEMIES

THE ILLINOIS STATE ACADEMY OF SCIENCE

THE twenty-fifth annual meeting of the Illinois State Academy of Science was held at the University of Chicago on May 6 and 7, 1932. General addresses were given on the following subjects: "Twenty-five Years of the Academy of Science," M. M. Leighton, chief, State Geological Survey, Urbana; "Glacial History of the Chicago Area," J. Harlen Bretz, University of Chicago; "The National Forest Movement in Illinois," L. E. Sawyer, State Natural History Survey, Urbana; "The Coming of Man," Fay-Cooper Cole, University of Chicago, retiring president.

Resolutions were adopted protesting against the contemplated action of Congress in reducing so severely the appropriations for scientific research, and in support of the establishment of National Forest purchase units in southern Illinois.

There were ten sectional meetings held, including the organization meetings of sections in anthropology and agriculture. The programs of three sectional meetings were devoted to symposia on the following subjects: Agriculture—"Recent Changes in Food Habits and Their Causes"; Anthropology—"Illinois Prehistory"; Economics—"Taxation." The section of physics and chemistry voted to organize separate sections in the two sciences for the 1933 annual meeting.

The meeting was attended by about 700, including about 200 delegates of high school science clubs, who attended the meeting of the junior section. Exhibits prepared by members of high school science clubs were shown, and prizes awarded. Opportunities were afforded for those attending the meeting to visit the Belfield Experimental Museum of Physics, the New Oriental Institute at the University of Chicago, the Adler Planetarium, the Shedd Aquarium and the Field Museum of Natural History.

The officers elected for 1932–33 were:

President: Harry F. Ferguson, State Department of Public Health, Springfield.

First Vice-President: A. C. Noe, University of Chicago.

Secretary: Harold R. Wanless, University of Illinois.

Treasurer: George D. Fuller, University of Chicago.

Librarian: A. S. Coggeshall, State Museum, Springfield.

Editor: Dorothy E. Rose, State Geological Survey, Urbana.

The following were chosen as chairmen of committees:

Membership: D. L. Carroll, State Geological Survey, Urbana.

Affiliation: J. C. Hessler, Knox College, Galesburg.

Ecological Survey: A. G. Vestal, University of Illinois.

Conservation: H. C. Cowles, University of Chicago.

State Hall of Fame: M. M. Leighton, State Geological Survey, Urbana.

Sectional chairmen selected for the 1933 annual meeting are:

Agriculture: H. W. Mumford, University of Illinois.

Anthropology: A. R. Kelly, University of Illinois.

Botany: H. S. Pepoon, State Natural History Survey, Urbana.

Chemistry George C. Ashman, Bradley Polytechnic Institute, Peoria.

Geography: Ruby Harris, Eastern Illinois State Normal School, Charleston.

Geology: J. E. Lamar, State Geological Survey, Urbana.

Junior: A. E. Cockrum, West Chicago.

Medicine and Public Health: N. O. Gunderson, Rockford.

Physics: Otis B. Young, Southern Illinois State Normal School, Carbondale.

Psychology and Education: Ralph W. Pringle, Illinois State Normal University, Normal.

Zoology: W. P. Hayes, University of Illinois.

HAROLD R. WANLESS,
Secretary

THE NEW HAMPSHIRE ACADEMY OF SCIENCE

THE thirteenth annual meeting of the New Hampshire Academy of Science was held on May 27 and 28, 1932, at Wolfeboro, New Hampshire.

On Friday night, May 27, the academy was addressed by Professor Charles Proctor, of Dartmouth College, on "Duck Hawks." The lecture was illustrated by many slides and by moving pictures showing the nesting habits, the rearing of the young and the day-by-day life of the parents and the young. The pictures were secured from a blind that was

lowered from the top of a steep high cliff to within eight feet of the nest.

On Saturday morning papers were read and discussed by members of the academy, and a visit was made to the Libbey Museum. In the afternoon the papers remaining on the program were read, and the retiring president, Professor J. W. Goldthwait, delivered the presidential address, "The Destruction and Preservation of Nature in New Hampshire."

At the business meeting the officers elected for 1932–33 were:

President, Professor Norman E. Gilbert, physics department, Dartmouth College.

Vice-president, Mr. Samuel P. Hunt, New Hampshire Public Service Company, Manchester.

Secretary-Treasurer, Professor Thomas G. Phillips, department of agricultural and biological chemistry, University of New Hampshire.

Member of Executive Council, Professor J. W. Goldthwait, geology department, Dartmouth College.

GEO. W. WHITE,
Retiring Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODIFIED MEDIUM FOR PLATING L. ACIDOPHILUS

In a previous communication,[1] a special agar medium was reported for the routine plating of *L. acidophilus*. Within the past year a modification of this medium has been developed which has proved more efficient.

In preparing this modified medium, 1 per cent. Difco peptonized milk is added to the original formula. Since the original medium was first reported, several details of preparation have been changed for reasons not evident at the time of the previous report. Because these have a pertinent bearing on the quality of the medium, the detailed method for the preparation of the new modified medium follows.

Mixture A: Add ten grams Difco peptone and 10 grams Difco peptonized milk to 400 cc of juice filtered from a good quality of canned tomatoes. Heat this mixture gently to dissolve the peptone and peptonized milk. Unnecessary heating of the tomato juice should be avoided. The reaction of the solution is changed to pH 6.0–6.2. There should be little deviation from this suggested reaction.

Mixture B: Add 11 grams dried agar to 600 cc distilled water and autoclave this mixture to dissolve the agar.

Just previous to the removal of Mixture B from the autoclave, bring Mixture A to the boiling point. Then mix A and B while both are hot and filter through a thin layer of absorbent cotton. Distribute the filtered medium in containers (test-tubes preferred) and sterilize by heating in the autoclave at 120° C. for eight minutes.

The properly prepared medium at this point is a clear agar, of a light brown color, having a final reaction of pH 6.0–6.2.

The reaction of the finished medium must not deviate very much from pH 6.0. When this medium was first developed, the reaction before autoclaving was adjusted to pH 7.2–7.4. During the sterilizing process, there was a decided drop in the pH, the final reaction sometimes being as low as 6.0. LaMer, Campbell and Sherman,[2] quoting the work of Nef, have reported that during the heating of an alkaline tomato juice the acidity increases considerably, due to the decomposing action of the hydroxyl ions on the sugars, resulting in the formation of organic acids. In an acid medium this analysis does not take place when this material is heated and, hence, the reaction remains quite stable. In our experimental work the pH of an acid tomato agar (pH 6.0) did not change after being held at 120° C. for 20 minutes.

Recently we made the interesting discovery that some strains of the X-type *L. acidophilus* develop very poorly in the tomato medium if the finished product has a reaction of pH. 6.8–7.0, especially when only a small amount (5 per cent.) of CO_2 is added to the incubation atmosphere. A method for incubation of agar plating of *L. acidophilus* in an atmosphere containing from 5 to 20 per cent. of CO_2 has been previously described by the senior author.[3] Further observation brought to light the fact that a tomato medium, which because of its reaction before sterilization (pH 7.2–7.4) had dropped to pH 6.0–6.2, would support a very good development of *L. acidophilus* colonies. Continued study indicated that most strains of X-type *L. acidophilus* will not develop well in a tomato medium with a reaction near the neutral point. When this same medium is acidified to pH 6.0–6.2, it becomes very satisfactory. It is possible that the chief function of added CO_2 in the incubation atmosphere is to lower the pH. This deduction is strengthened by the observation that a tomato medium of pH 6.0 reaction will support a very good growth of *L. acidophilus* without the addition of CO_2 to the incubation atmosphere. However, the development without added CO_2 is not quite as great as when this gas is used. The exact relationship of these two factors (CO_2 and reaction) in this particular case is under further investigation.

The modified medium, prepared as described, has

[1] SCIENCE, lxvi, 1927, pp. 512–513.

[2] *Journal of American Chem. Society*, 44, 1922, pp. 172–181.

[3] SCIENCE, lxiv, 1926, pp. 304–306.

proved more satisfactory because *L. acidophilus* develops larger colonies than are produced in the original medium. Quantitative plate counts are also usually higher with this new medium. Extensive comparative tests have indicated that this medium is as good or better than any of the more complicated digest mediums previously advocated by the senior author and others for plating *L. acidophilus*.

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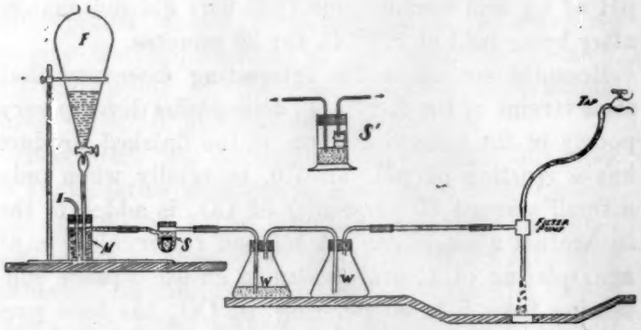
APPARATUS FOR VERY GRADUAL CHANGE OF FLUIDS

THIS apparatus, as set up in the text figure, is recommended in the treatment of tissues used for cytological studies. It also can be used for specimens which do not require a gradual change and can be run through the alcohols more rapidly. The tissues to be treated are placed in a perforated crucible and the crucible is stoppered with a finely perforated cork.



This crucible is placed in the specimen bottle (S). The replacing fluid in the Walter's special separatory funnel for single drops (F) is started dropping at the desired rate, the flow being regulated by the stopcock. The suction from the filter pump draws air from the inlet (I) through all the containers and carries the excess fluid from the mixing bottle (M) and the specimen bottle (S) into the waste bottle (W). The air bubbling into the mixing bottle (M) will insure a quick and thorough mixing of the fluids in both the mixing bottle (M) and the specimen bottle (S).

For smaller and more delicate specimens the specimen bottle (S'), shown in the inserted diagram, may be used. This is constructed by cutting the bottom from a small homeopathic vial, tying a piece of bolting silk to the stopper-end of the vial to prevent loss of specimens in the outlet tube, and attaching this vial to the outlet tube by means of a cork.

For higher alcohols or clearing agents the air passing into the inlet (I) should be dried by passing it through a calcium chloride tube or through a bottle containing sulphuric acid or absolute alcohol. Very little water can be absorbed from the waste bottle (W) since the air currents will pass away from the specimen bottle (S) and toward the waste bottle (W). It is necessary to introduce a second waste bottle in order to prevent a back-flow of the water from the filter pump in case the water pressure from the tap is reduced.

Large specimens, such as termatodes, have been successfully transferred from 95 per cent. alcohol to water in three hours. The success is probably due to the constant mixing of the fluids before coming into contact with the specimens instead of the usual abrupt change from one grade of alcohol to the other. This apparatus facilitates washing since it can be done in the same container in which the specimens can be stained and run up through the alcohols.

(This apparatus was constructed through the courtesy of the Empire Laboratory Supply Company of New York City.)

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SPECIAL ARTICLES

FERROUS IODIDE AS A SUBSTITUTE FOR VITAMIN A IN RATS[1]

IN view of the observations of Chidester, Eaton and Thompson[2, 3] that small doses of syrup of ferrous iodide can substitute for vitamin A in the cure of xerophthalmia and promotion of growth in rats on vitamin-A deficient diets, the author has reinvestigated this subject, using the same dosage of ferrous iodide, and supplying irradiated ergosterol as a source of vitamin D throughout the experiment. Observations include the effect of ferrous iodide on (1) xerophthalmia, (2) terminal infections of the glands about the mouth, (3) age at which xerophthalmia appears, (4) age at which constant weight is reached, (5) age at death, (6) weight at death, and (7) food consumption.

The animals used were albino rats from a stock raised for generations on Sherman Diet 13, and were placed at 4 weeks of age on Sherman vitamin-A free

[1] Published with the approval of the Director, West Virginia Agricultural Experiment Station, as Scientific Paper No. 107.

[2] F. E. Chidester, A. G. Eaton and G. P. Thompson, SCIENCE 68, 1766, 432, 1928.

[3] F. E. Chidester, A. G. Eaton and N. K. Speicher, *Proc. Soc. Exper. Biol. & Med.* 28, 187, 1930.

diet No. 380 plus irradiated ergosterol (1 mg per 1,000 gms of diet). Two series were studied: Series I, in which the syrup of ferrous iodide, 1–350 dilution, was given daily, in doses of 3 or 5 drops, as a curative measure, after xerophthalmia had developed; and Series II, in which the iodide solution was given daily in the same dosage, as a preventive measure, from the beginning of the experimental period. The animals were compared with litter mates on the same diet, but without added iodide solution; and also with control rats receiving cod-liver oil as a source of vitamin A, with and without iodide solution. Since the control rats were consistently negative for xerophthalmia, terminal infections, or other pathology, they are not included in the results given here.

In Series I, 45 rats were given iodide treatment daily, when xerophthalmia appeared—usually at about 9 weeks, when constant weight was reached; and were compared with 21 litter mates on the same diet without added iodide solution. The dilute syrup of ferrous iodide was made up fresh each week, and given to the individual rats daily by pipette, calibrated to deliver drops of the solution containing 0.000098 grains of iodine, and 0.0000216 grains of iron. Treatment was continued until death, when autopsy was performed. Weights were taken once or twice a week, and observations made on the eyes three times a week. Three criteria of xerophthalmia were used: (1) swelling of the lids, (2) appearance of blood, first at the inner canthus, later generalized over the lid; and (3) exudate, first serous, later purulent. The degree of these symptoms was described from day to day by plus signs, grading from (+) to (+++).

In practically all the animals, bleeding about the eyes was the same in amount and character in the treated as in the untreated rats; and there was no detectable difference in the swelling or exudate. In a few cases, the iodide seemed to exert a temporary inhibiting effect on bleeding about the eye; but bleeding always reappeared, and xerophthalmia progressed through the usual stages. Since this same phenomenon appeared in a few of the untreated rats also, it can not be regarded as due to the iodide.

Iodide treatment had no effect whatever on the incidence of terminal infections of the glands about the mouth so characteristic of vitamin-A deficient rats. In 100 per cent. of the animals, both with and without iodide treatment, pus was found at death in one or more of the following loci: submaxillary gland, sublingual gland, thyroid, nasal sinuses, and frequently in the middle ear.

Death was hastened by ferrous iodide by an average of 12 days; although the weight at death was about the same for iodide treated as for untreated rats, the difference being 5 grams or less. Food consumption was decidedly less in the iodide treated rats, the average difference being 25 grams, and probably representing what might be expected from the shortened life of the rats treated with iodide.

In Series II, 18 rats were given daily doses of 3 or 5 drops of dilute syrup of ferrous iodide from the beginning of the experimental period, until their death. When so given, the iodide had no effect upon the incidence of terminal infections of the glands about the mouth, nor upon the incidence or course of xerophthalmia, although it did delay the onset of xerophthalmia, and the time of appearance of constant weight and death. It also increased the food consumption.

The results of these experiments, therefore, confirm the work of Mason,[4] who found syrup of ferrous iodide without effect on the xerophthalmia of vitamin-A deficient rats, and further show that ferrous iodide can not substitute for vitamin A in the cure or prevention of terminal infections characteristic of vitamin-A deficiency in rats.

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DUAL ENDOCRINE ACTIVITY OF THE TESTES

EXPERIMENTS, the results of which are now being prepared for publication, and a review of the literature, establish the following facts:

(1) The castration of male rats results in changes which can be placed in two distinct groups, namely, (a) those in which secondary sex characteristics are lost and the secondary sex glands (prostate and seminal vesicles) atrophy, and (b) those in which the pituitary gland undergoes hypertrophy and becomes hyperfunctional; the adrenals also hypertrophy.

(2) Testicular extracts prepared with fat solvents will prevent the atrophy of the secondary sex glands if administered immediately after castration. If the glands are permitted to atrophy the testicular extracts will cause regeneration.

(3) The comb-growth-promoting substance from male urine[1] has the same physiological properties as the hormone extracted from testes. The known chemical and physical characteristics of the hormone from testes and that from urine would indicate that they are identical.

(4) The hormone from urine or blood is derived from the testes since it is not found in the body fluids of castrated men, although it is readily demonstrable in normal men.

[4] Karl E. Mason, *Anat. Record* 51, No. 1, Supplement, 57 (1931) Abstract.

[1] Formula $C_6H_{26}O_2$—A. Butenandt, *Zeit. für Angewandte Chemie*, 1931, 46, S. 905.

(5) Such a hormonal preparation from urine, when given in doses sufficiently large to cause regeneration of the atrophic secondary sex glands of castrated rats, will neither prevent nor correct the hypertrophy of the pituitary gland and adrenals after castration.

(6) Aqueous testicular extracts, which could have contained no more than an insignificant amount of the prostate-regenerating hormone, prevent the cellular changes from appearing in the pituitary gland after castration of rats and also completely inhibit the hyperfunction of the pituitary gland.

(7) Destruction of the germinal epithelium of the testes will cause pituitary hyperfunction without causing atrophy of the secondary sex glands.

The apparent and only obvious conclusion is that the testicle secretes a hitherto unrecognized water soluble hormone, one function of which is a control of the pituitary gland.

To facilitate discussion, it is essential that the two testicular hormones be differentiated. Using the Greek root "andros" the name "androtin" has been suggested for the benzene soluble substance which is responsible for the development and maintenance of the secondary sex glands and other secondary sex characteristics. This name corresponds in derivation to the name "theelin" suggested by Doisy for the ovarian hormone. The water soluble testicular factor, which is characterized by its action on the pituitary gland, has been called "inhibin" from the Latin verb "inhibere."

The arguments in favor of the presence of two testicular hormones are almost but not absolutely conclusive. It has been demonstrated that "inhibin" in doses which do not influence the secondary sex glands will prevent the hyperfunction of the pituitary gland of castrated animals. Also, as mentioned above, "androtin" in doses sufficient to cause regeneration of the atrophic prostate of castrated rats will not prevent the hypertrophy and hyperplasia of the pituitary gland. It remains to be shown whether or not hyperfunction accompanies hyperplasia and hypertrophy. Fortunately this point can readily be established by available experimental procedures.

There is but the remotest possibility that the established facts can be explained on a basis of hormonal dosage.

The hypothesis of the duality of testicular endocrine function has been developed to explain well-controlled animal experiments. In addition to this experimental evidence there are certain general considerations which lead to the belief that there might be two hormones secreted by the male gonads. The testicle is the male analogue of the ovary. "Androtin" is comparable physiologically and chemically to theelin. Until now there has been no suggestion of a testicular hormone comparable to ovarian progestin. The idea that the testicle produces two hormones is compatible with the histology of the gland.

Prostatic hypertrophy as observed clinically in many adults beyond middle age has had no satisfactory explanation. It is now a well-recognized fact that the pituitary gland can stimulate the testes to the production of sufficient "androtin" to cause prostatic hypertrophy in rats. If the testicular cells producing "inhibin" were to fail, previous to the failure of those structures which produce "androtin," the hypertrophic phenomenon could easily be explained. The absence of "inhibin" would result in hyperfunction of the pituitary gland which, as pointed out above, is a known cause of prostatic hypertrophy in rats. The brilliant researches of Martins and Rocha indicate that there is every possibility that "inhibin" is not produced when the germinal epithelium is destroyed. The destruction of the germinal epithelium does not change the secondary sex characteristics which are maintained by "androtin."

In closing I should like to point out that although nearly all of the experimental facts presented have been established or confirmed in this laboratory, this hypothesis could not have been established had it not been for years of careful investigation in many other laboratories. In particular I wish to thank Professor E. C. Dodds for much assistance received from personal communications concerning the researches on "androtin."

A more intensive study of "inhibin" and "androtin" is now in progress in this laboratory.

D. ROY MCCULLAGH

CLEVELAND CLINIC FOUNDATION

BOOKS RECEIVED

CHALK, L., J. BURTT DAVY and H. E. DESCH. *Forest Trees and Timbers of the British Empire:* Some East African Coniferae and Leguminosae. Pp. 68. Illustrated. Oxford University Press. $1.75.

HEINTZ, ANATOL. *The Structure of Dinichthys; A Contribution to our Knowledge of the Arthrodira.* Pp. 115–224. 90 figures. 9 plates. American Museum of Natural History.

LANE, ERNEST P. *Projective Differential Geometry of Curves and Surfaces.* Pp. xi + 321. 40 figures. University of Chicago Press. $4.00.

NEWSHOLME, SIR ARTHUR. *Medicine and the State.* Pp. 300. Williams & Wilkins. $3.50.

OLSEN, JOHN C. *Unit Processes and Principles of Chemical Engineering.* Pp. xiv + 558. 165 figures. Van Nostrand. $5.00.

REINIG, W. F. *Beitrage Zur Faunistik des Pamir-Gebietes.* Vol. I, Pp. viii + 195. 29 figures. Vol. II, Pp. 196–312. 14 plates. Reimer und Vohsen, Berlin.

SHERMAN, HENRY C. *Chemistry of Food and Nutrition.* Fourth edition, revised. Pp. xiii + 614. Macmillan. $3.00.

[2] *Endocrinology*, 1931, Vol. 15, p. 421.